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Enhancing pulp and paper uptime and profitability with Distributed Control Systems (DCS) and Safety Systems

How leading pulp and paper companies are adopting intelligent control and 4IR capabilities to increase productivity, automation, and protection

Executive summary

Pulp and paper manufacturers are at an important inflection point. To better navigate the simultaneous challenges of intensifying global competition, dynamically changing product demand, rising raw material costs, and the mass retirement of skilled workers, pulp and paper companies are ramping up digitization and automation. Manufacturers that embrace this shift are forging new ways to profitably compete in a highly dynamic marketplace. Across pulp and paper companies, key outcomes are improved production efficiency, more intelligent uptime, minimized downtime and enhanced safety.

Central to this digital shift and the resulting outcomes, are Distributed Control Systems (DCS) and Safety Systems. These solutions, based on smart, data-driven approaches and automation, are helping pulp and paper manufacturers on the journey toward automation, and ultimately to Industry 4.0 (the fourth industrial revolution).

This whitepaper leverages insights from interviews with 40 global pulp and paper manufacturers on how DCS and Safety Systems are transforming operations, driving outcomes and catalyzing automation. Data and control from these systems will also benefit the expansion into broader solutions such as IoT (Internet of Things), AI (Artificial Intelligence), and ML (Machine Learning). Leading pulp and paper companies are using DCS and Safety Systems to pave the way forward and improve their productivity, profitability, and ultimately, their viability.

The challenge

Concurrent challenges across the pulp and paper industry are impacting manufacturers around the world. Across geographies and company size, no pulp and paper company is exempt. Increasing global competition has driven down pricing and squeezed profit margins. At the same time, raw material costs are escalating, and changes in demand from a volume and product mix standpoint put additional pressure on profitability and operational capabilities. Layered on top of these trends is the mass retirement of skilled workers, which is depleting the experience and skill base in highly sophisticated pulp and paper operations. Lastly, the impending move to Industry 4.0, or 4IR, is challenging pulp and paper companies, as it requires investment and represents significant change.

These simultaneous forces across the pulp and paper industry are necessitating next-level operational optimization to better manage costs and production efficiencies. Leading pulp and paper manufacturers are investing to manage these challenges and those investments must accomplish two core things:

1. **Self-fund.** Provide real outcomes today that also help to "self-fund" the multi-year journey to 4IR.

   Key outcomes include:

   + Better operational optimization
   + Increased cost reductions
   + Enhanced safety

2. **4IR Integration.** Integrate into the overall journey to 4IR so that there is a long-term roadmap and payoff vs. a "rip-and-replace" approach.

   + Of the 40 pulp and paper companies interviewed, 85% have started, or are currently building, 4IR capabilities
   + 4IR and the capabilities it provides, will be a key determinant of global competitiveness and future viability

The four industrial revolutions

Industry 1.0: STEAM

The industrial age began with advances in science and mechanics that enabled water and steam power to mechanize production such as in steam engines and railways.

Industry 2.0 ELECTRICITY

The second industrial revolution used electric power to create mass production.

Industry 3.0 COMPUTING

The third industrial revolution, was catalyzed by the invention of the semiconductor, using electronics and information technology to automate production.

Industry 4.0 CYBER-PHYSICAL SYSTEMS

The fourth industrial revolution leverages different technologies like human-machine interaction, robotics, cyber devices, and much more. It is often described as the fusion between physical, digital and biological worlds.

You can learn more about 4IR in this two-part podcast series.

What is 4IR?

Let's start with a definition of 4IR. In general terms, 4IR is a period of rapid technological growth in which disruptive technologies and trends are changing the way we live and work. Technologies such as Internet of Things (IoT), virtual reality (VR), artificial intelligence (AI), and machine learning (ML) are integrating into manufacturing processes. The adoption and integration of these technologies and the capabilities they bring are called Industry 4.0 or 4IR (the 4th industrial revolution).

4IR capabilities

What new capabilities will 4IR encompass and enable in the manufacturing sector? Here are some of the novel and interlinked competencies that will usher in this profound transformation.

Internet of Things (IoT) and Industrial Internet of Things (IIoT). The growing network of connected objects that collect (via sensors) and exchange data in real-time is known as the Internet of Things or, in industrial environments, the Industrial Internet of Things. IoT and IIoT enable the interconnected communications that power 4IR.

Sensors. Low power, low cost sensors and smart sensors are the building blocks to 4IR and smarter manufacturing. Sensors monitor, measure, collect and communicate data that feeds 4IR applications.

Analytics. Data is great, however, it's real value is derived from the analytics that create actionable insights from that data. In simple terms, analytics use data and math to uncover relationships and predict future outcomes.

Algorithms. Tailored algorithms that can be asset-, process- or industry-specific work together with analytics to make a prediction or decision that enables smarter corrections on machines or processes.

Artificial Intelligence (AI). Using computer processes (including analytics and algorithms), artificial intelligence mimics human intelligence, providing competencies such as decision-making and image recognition.

Machine Learning (ML). Machine learning is a specific type of artificial intelligence where systems are able to learn automatically and progressively, without explicit programming.

Robotics/advanced robotics. As artificial intelligence progresses, more sophisticated robotics will replace and enhance manual industrial tasks. One estimate states that, in 2020, over 3 million industrial robots were in use globally.

Robotic Process Automation (RPA). Robotic process automation is a software technology that leverages digital workers or software robots to emulate humans actions and interact with digital systems software (i.e. read a computer screen and follow instructions on the screen).

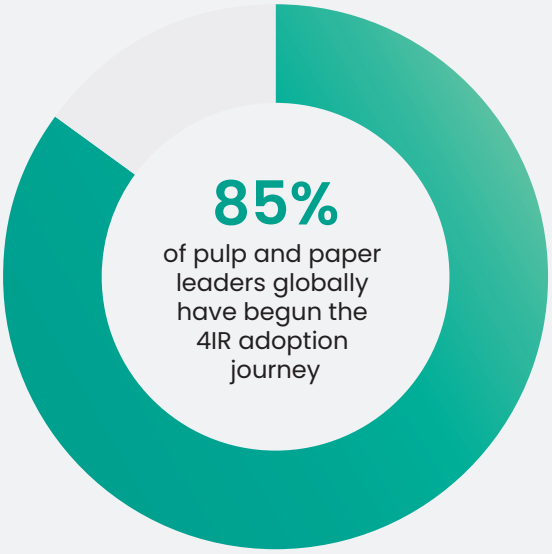
Automation. Automation is, as the name implies, when manual processes and decisions are automated using analytics, computer programming and robotics.

Edge computing. As computing power and the cloud increase to meet the needs of 4IR, so must the cybersecurity measures to protect manufacturing processes. Edge computing, which moves computing power closer to the data generation source, helps to bolster security, provide faster data processing and helps to optimize bandwidth.

Virtual Reality (VR) and Augmented Reality (AR). Simulation via VR or AR can be used in a multitude of ways in manufacturing: From speeding up production lines, maintenance assistance, education and collaboration, assembly, to testing and digital prototyping.

What does 4IR mean for pulp and paper manufacturers?

The promise of 4IR is greater productivity, efficiency and control. The majority, an estimated 85%, of pulp and paper leaders around the world are planning or have begun the 4IR multi-year journey. In many cases, an initial first step is the adoption of a modern Distributed Control System (DCS) and Safety System. Let's take a look at why this is an early step, how it can deliver results in the short-term to "self-fund" further investments and then integrate into 4IR capabilities as they are built, as well as the specific benefits DCS and Safety Systems can provide.



The opportunity

(What leading pulp and paper manufacturers are doing)

The mantra, "with great change comes great opportunity", is an apt statement to describe the opportunity for pulp and paper operations. As leading pulp and paper companies adopt, update and leverage DCS and Safety Systems today, there are two key tenets that justify the investment and implementation.

1. **Optimize operations today.** Improved operational outcomes are needed today (and urgently) in order to successfully navigate the multiple challenges and profitability pressures that pulp and paper manufacturers are facing.

   Distributed Control Systems and Safety Systems are designed with diagnostic capabilities to improve control reliability and performance. These intelligent systems are mainly used in environments where multiple processes are involved – such as pulp and paper manufacturing -- and have automated control features that can overcome complicated processes or dangerous thresholds being reached at the time of production.

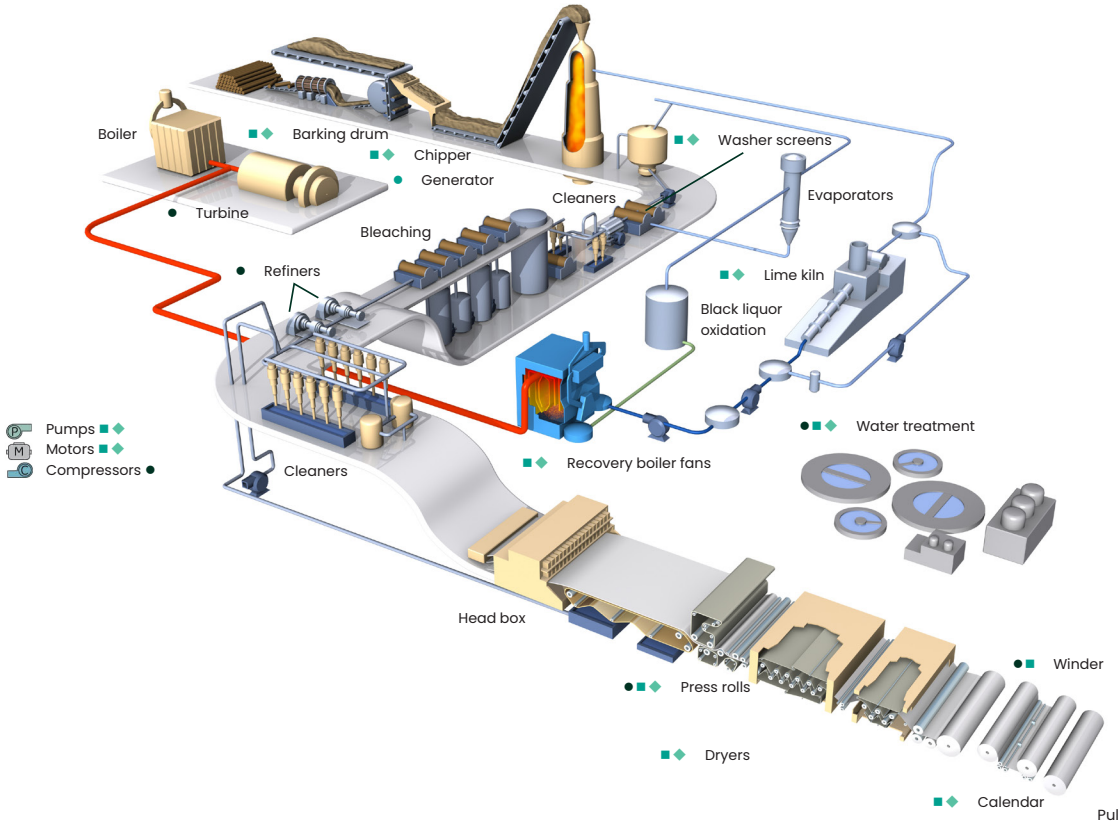
   The pulp and paper diagram shows the assets (pumps, motors and compressors) that comprise the multiple processing areas within the plant. The operation of many of these assets can be optimized and more safely controlled via DCS and Safety Systems.

Let's look at a couple applications:

➲ **Digester controls.** A paper mill producing liner board for the shipping industry was struggling to achieve its daily production target due to inconsistent digester operation. An aging DCS system was increasingly unreliable, adversely impacting the digester cooking process. This resulted in a domino effect of runtime issues cascading from stock preparation through to the paper machines. A new, upgraded DCS system was installed, facilitating increased throughput via previously "maxed out" washer lines, resulting in fewer breakdowns. Project payback happened in less than three months at a **300% rate of return** and the modern DCS is continuing to generate medium and long term positive benefits.

➲ **Recovery boiler.** Another recent pulp and paper example required modernizing a DCS system, as the existing one was failing to effectively prevent downtime occurrences. The existing DCS for this plant ran the recovery boiler, evaporators, mill air and water systems, turbine generator interface, deionized water plant, boiler feedwater pumps, the common steam headers, and condensate systems. After 7 months of planning and design, a new replacement DCS was installed within 72 hours. As a result, **downtime has been reduced from a regular problem to a rare occurrence**, improving efficiency and overall plant productivity.

Example diagram of a Pulp & Paper plant



Distributed Control Systems contain multiple controllers, which can communicate and manage operations under a common HMI (Human Machine Interface) management platform. The following are some benefits of Distributed Control Systems and Safety Systems:

+ Eliminates redundant processes and automates production units
+ Helps in controlling complicated, large, and geographically distributed manufacturing applications
+ Minimizes production costs and processes
+ Provides flexibility and extends plant equipment / assets useful life
+ Provides automatic shutdowns in case certain dangerous thresholds are reached
+ Allows for flexibility on how certain systems are controlled.
+ Brings real time control as close to the process as possible while still being monitored from a central location

As a result, the key benefits of next-generation DCS and Safety Systems include:

+ Smarter uptime
+ Improved production efficiency
+ Additional cost reductions (from operational optimization)
+ Minimized downtime
+ Enhanced safety
+ Ability to be used by less experienced staff to offset the maturing workforce

Safety Systems (Source: IEC 61511 standard) are designed to protect people, processes, assets and the environment from unsafe events. A Safety System can

1. Prevent an unsafe event from happening via an automated shutdown if asset threshold levels are passed.

OR

2. Mitigate the severity of an event by taking the process to a safe condition.

There are standards governing the safety systems and levels of reliability to ensure that the safety system works correctly or fails in a predictable, or safe, way.

The three major components of a Safety System include:

+ **Safety Instrumented System (SIS).** Comprised of sensor(s), logic solver(s) and final element(s), the SIS is designed to run the Safety System and prescribe automated shutdowns or alter the process to reach safe operating conditions.
+ **Safety Instrumented Function (SIF).** The SIF instructs the SIS which function to execute in order to maintain a safe state.
+ **Safety Integrity Level (SIL).** SIL indicates the reliability of the safety instrumented functions or its probability to fail on demand. SIL targets, shown below, are based on the risk frequency and severity. Equipment can be graded as "SIL capable" or "SIL certified", to meet compliance standards.

Safety integrity level (SIL)	Probability of failure on demand (PFD average)	Target risk reduction (RRF)
4	$\geq 10^{-5}$ to $< 10^{-4}$	> 10,000 to ≤ 100,000
3	$\geq 10^{-4}$ to $< 10^{-3}$	> 1,000 to ≤ 10,000
2	$\geq 10^{-3}$ to $< 10^{-2}$	> 100 to ≤ 1,000
1	$\geq 10^{-2}$ to $< 10^{-1}$	> 10 to ≤ 100

2. **Institute a key building block to 4IR via complete integration capabilities.** With the impending transition to 4IR, the litmus test for technology investments is the ability to integrate into the future 4IR state. DCS and Safety Systems are a building block that can both integrate and further enhance 4IR capabilities. Some of the specific benefits of a next-generation, modern DCS that can empower 4IR competencies include:

   + Automate real-time control
   + Mitigate unplanned downtime
   + Elevate intelligent uptime (and recovery)
   + Enable data collection, storage and usage requirements for AI, ML, VR (Artificial Intelligent, Machine Learning, Virtual Reality)
   + Provide simple HMI (Human Machine Interface), built on sophistication, which can be leveraged for broader production virtualization or simulation and process control
   + Leverage tailored analytics to use performance data for predictive maintenance, analyze workflows and optimize operational efficiency.

Thus, leading pulp and paper companies are leveraging DCS and and Safety Systems to optimize operations today while simultaneously instituting a building block to 4IR with strong integration capabilities. Let's look at some real-life examples from geographies all around the world.

+ Example 1. ASIA

An Asian-based pulp and paper manufacturer is implementing IIoT-enabled (Industrial Internet of Things) solutions that will drive operational and energy efficiency. The IIoT will connect across operations and linked network devices. Together with a DCS, this will drive better decision-making throughout operations.

+ Example 2. NORTH AMERICA

A large multinational paper manufacturer headquartered in the U.S. recently inaugurated a data pilot project. The goal is transitioning from analysis of historical data to predictive maintenance based on recommendations made by a machine-learning (ML) engine, which requires large volumes of historical and real-time data. Systems such as this work hand-in-hand with DCS and Safety Systems to achieve next-level operational control and enhanced safety.

+ Example 3. EUROPE

A large European-based paper manufacturer has implemented Machine Learning to predict paper quality, and deployed algorithms to predict failures and increase the sampling rate for better root cause analysis. DCS data collection and HMI (Human-Machine Interface) capabilities are a helpful enabler and stepping stone to machine learning competencies.

+ Example 4. SOUTH AMERICA

In one South American paper mill, a highly sophisticated and intuitive HMI is being used to virtualize the entire production process via data analytics, big data and cognitive intelligence.

The solution

(What you should do)

ONE. First and foremost, many leading pulp and paper manufacturers recognize that all DCS and Safety Systems are not created equal. Modern DCS and Safety Systems are needed to help pulp and paper companies more effectively compete, today.

TO DO: Upgrades to modern systems are required in order to reap the benefits of automated control, data collection and data analysis into actionable insights and quick access to application logic. The outcomes are smarter uptime and increased throughput which helps to balance the opposing pressures on profitability faced throughout the pulp and paper industry.

In the case of unplanned downtime in pulp and paper operations, the ability to make critical, data-driven decisions enables both accuracy and speed in returning to normal operations. Across manufacturing, unplanned downtime can make or break operational profits. Leading pulp and paper manufacturers properly mitigate the production, financial and safety risks that can quickly escalate and stem from unplanned downtime. They do this through the adoption of next-generation DCS and Safety System solutions – to optimize operations, productivity, and ultimately, profitability and viability.

TWO. Secondly, the ability to optimize operations also requires a simple interface that manages control of multiple sophisticated processes and operation-wide data.

TO DO: Leverage next-generation DCS HMI as a universal interface. next-generation DCS and Safety Systems offer HMI integration to other systems and applications, providing a single "window to the process" with a common HMI platform. This provides operators with a simple and sophisticated access point from which to achieve broader and higher-order optimizations.

For example:

+ As 4IR advances, a single DCS HMI could blend digital operations such as AI and ML in one data visualization package that links to process alarms and conditions.
+ The DCS HMI could be integrated with a Quality Management System so that operators could make real time adjustments to processes and address quality issues.
+ A single DCS HMI could integrate with an ERP (Enterprise Resource Planning) system to address real time changes in demand.

THREE. Thirdly, next-generation DCS implementations are able to fully leverage analytics and data-driven insights.

TO DO: Utilize next-generation DCS that have the ability to connect to third party systems and applications via IIoT, and leverage a broader data set and analyze it for deeper insights. Some examples include leveraging models to optimize equipment such as reciprocating compressors and boilers, analyze control loops and make recommendations for tuning, and determine when field devices require recalibration.

Getting started

For pulp and paper manufacturers, achieving safe, cost-effective operations requires the ability to avoid unplanned downtime and – if it occurs, then rapidly recover. To compete more effectively, leveraging smarter uptime and data-driven capabilities delivers returns today and sets the stage for the transition to 4IR. DCS and Safety Systems provide these competencies in the high stakes manufacturing environment of pulp and paper operations.

When choosing a DCS and Safety System provider, it is critical to select the right solutions from an industrially minded partner with deep and proven expertise in automated safety and distributed control solutions. The first step is a review of current DCS capabilities and its readiness for 4IR applications. An understanding of DCS integration capabilities and other next-generation features will uncover whether or not the current system is able to catalyze the 4IR journey.

Summary

Pulp and paper companies are at an inflection point due to increasing global competition, rising raw materials costs, shifting demand patterns, mass retirement of skilled workers, and the impending fourth industrial revolution. Leading pulp and paper companies are ramping up digitization and automation toward comprehensive 4IR capabilities, however, this process is a multi-year, complex journey. Improved operational outcomes are needed today.

Thus, pulp and paper companies are leveraging next-generation DCS and Safety Systems to elevate competencies while paving the way to 4IR. Manufacturers that embrace this multi-layered digital shift are forging new ways to profitably compete in a highly dynamic marketplace. In pulp and paper companies, key outcomes are improved production efficiency, more intelligent uptime, minimized downtime and enhanced safety, all urgently needed in today's pulp and paper manufacturing environments.

The research used in this white paper has been commissioned by Nexus Controls, a Baker Hughes business, and underwritten by MarketsAndMarkets Research Pvt Ltd, the world's largest revenue growth advisory firm.

About Nexus Controls

Nexus Controls LLC (formerly GE Energy Controls Solutions) exists as the collective experience and history of multiple companies whose expertise, knowledge, and lineage spans over 150 years.

Our global team of domain experts are in 44 countries on all six continents and have Successfully delivered over 11,000 successful projects in the power, oil & gas, and various industrial markets.

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Special thanks to our partner, Logical Systems, LLC (LSI), for contributing to this white paper. LSI is a global systems integrator specializing in process improvement, electrical engineering, automation, systems integration, and manufacturing intelligence (data intelligence, manufacturing execution systems, industrial control system/operational technology cybersecurity).

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